# THE PALLETIZED LOAD SYSTEM... JUST ANOTHER TRUCK?

A Monograph
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## ABSTRACT

THE PALLETIZED LOAD SYSTEM.... JUST ANOTHER TRUCK? by Major Daniel V. Sulka, USA, 61 pages.

This monograph examines the Palletized Load System to determine if it will effectively support the transportation requirements of current and evolving doctrine. The PLS, a self loading and unloading truck and trailer system, will be fielded in the near future. This technology represents a significant investment in addressing shortfalls in ammunition distribution under the Maneuver Oriented Ammunition Distribution System (MOADS).

To assess the impact of the Palletized Load System on logisticians' ability to support AirLand Battle doctrine and and the evolving AirLand Operations doctrine, the monograph first traces historical and theoretical influences on the system. These include the evolution of truck technology, the impact of mechanized transport and mobility on doctrine, and the development of unit load devices and containerization. The monograph briefly addresses current transportation challenges, the design of the Palletized Load System, and its planned use.

The monograph concludes that the Palletized Load System is a natural confluence of the evolution of transportation technologies and the demands of highly mobile forces. The PLS/MOADS application greatly enhances the logistician's ability to apply anticipation, integration, continuity, and responsiveness in support of ammunition resupply in AirLand Battle. However, restricting use of the PLS to ammunition distribution hinders improvisation and does not provide for a integrated, synergistic transportation system supporting all facets of mobility and logistics distribution. Finally, the monograph demonstrates that by leveraging emerging technologies, by continuing to seek and implement new logistics applications, and by integrating PLS capabilities into equipment and force design, this technology can greatly enhance AirLand Operations.

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## INTRODUCTION

Late next year, the Army will begin to field the Palletized Load System (PLS) to support ammunition resupply under the Maneuver Oriented Ammunition Distribution System (MOADS). The PLS is a self-loading and unloading tactical truck and trailer system. Both components have demountable cargo beds called flatracks. As an integral part of the system, these flatracks containing cargo are mounted or demounted from the truck with a hydraulically powered arm at the rear of the cab.

The PLS is an expensive new system. As with any significant new piece of equipment coming into the Army inventory, it has been the subject of intense study by systems analysts, efficiency experts, engineers, auditors, congressional staffs, and combat and force developers. The system continues to undergo extensive technical evaluation. But its utility has not yet been examined from a historical perspective.

The PLS has been hailed as a technological solution to challenges of transportation and distribution support for current and emerging U.S. Army war fighting doctrine. The purpose of this monograph is to determine whether the PLS will be the solution.

Historian Alex Roland writes that technology shapes war. Though not the only factor nor necessarily the most important, it has consistently influenced when and where

wars take place. Perhaps more importantly, it shapes how they are fought.[1] History reveals that some technical innovations drive the form and substance of military art. In other cases, the necessities of war have stimulated and given birth to invention. At times, it may have been a combination of the two. In either case, the benefit of developing the historical context for a technological innovation is an enlightened perspective.

A historical overview identifies broad trends and conditions that have influenced technological solutions to problems of warfare. Once noted, criteria that keep in mind these influencing factors are selected to determine the utility of these solutions. This should be the mechanism by which technology is integrated into military applications. But technology often enters military practice invisibly - documented only by historians. Theoreticians seldom act as advocates for innovation or rationalize the process as it occurs.[2]

A detailed analysis of exactly how a new weapon or innovation will affect the conduct of war can greatly aid in its most effective integration into the force.[3] Military equipment developers and force planners sometimes fail to assess the impact of a new technology on warfare at the time the technology was developed or employed. In these situations, history would provide a useful context for analysis.

As a first step in determining the utility of the system, this monograph will identify three broad historical

trends in technology influencing the development of the PLS and forming the theoretical basis for the concept. These are: the evolution and application of truck transportation in warfare, the symbiotic relationship of advances in transportation and mobility to the evolution of military doctrine and force design, and the development of unitized cargo or containerization technologies and concepts.

After examining the historical influences on the system, the next step will be to describe current transportation challenges, the design of the PLS and its planned application. The final step will use the imperatives of current and the concepts of future sustainment doctrine as criteria to determine the implications of this technological innovation. By assuring that military applications of PLS technology have both a visible and sound base, the innovation can be integrated most effectively into the force to solve doctrinal demands on transportation and mobility.

## HISTORICAL PERSPECTIVE OF TRUCK TRANSPORTATION

Since the late nineteenth century, military forces have employed mechanical transport powered by internal combustion engines for ground transportation. The internal combustion engine, favored over steam, provided the most reliable and efficient propulsion for vehicles. The key task in integrating this technology was to convert the potential energy of the internal combustion engine into increased combat power. The effort to harness the energy of mechanical transport focused

on two areas -- logistics and unit mobility.

For logistics, the effort was to exploit increased capacity and speed of cargo movement by replacing troops carrying their own supplies and animal powered conveyances with trucks. The increased flexibility of the truck provided armies great advantage over opponents dependent upon foraging or railroads for lines of communication.

One early example of mechanical transport was the use of tractors to pull ammunition wagons at the siege of Paris in 1870-71.[4] The British used primitive tractors to haul supply wagons during the Boer Wars.[5] In WW I the British and French gradually began to depend heavily on 3-ton lorries powered by internal combustion engines. These trucks linked railheads to the front lines for resupply of the massive armies. The horse drawn wagon had begun to disappear from the battlefield.[6]

At first, trucks were assigned to units to carry a single class of supply. But by 1918 motor vehicles were pooled into transport companies and used to haul supplies based on priority of need. Using trucks for supply distribution reduced dependence on the railroad. Materiel could now be efficiently hauled by truck when rail lines were threatened or cut.[7]

Pack animals and horse drawn wagons still played a significant role in sustaining most armies of World War II. However, by war's end, the truck had replaced livestock in all but the most rugged or remote regions. Even in nations

that had lost production capabilities or those which initially lacked the ability to manufacture vehicles, trucks became an essential component of the army. The Soviet Union received over 350,000 trucks as part of the Lend/Lease program to support the second front against Germany.[8]

These twentieth century wars illustrate two influential trends which increased the importance of logistics. The first is that modern weapons and the armies that used them required greater quantities of materiel to fuel and arm the machines.[9] Secondly, as Napoleon demonstrated in raising, maintaining, and motivating massive nationalist armies, the feeding and clothing of soldiers was as important as fueling or arming the machines. Other nations learned quickly how the well being of the troops was no longer a matter of secondary importance.[10] Maintenance of morale and the prevention of manpower losses from disease and deprivation repeatedly have been proven to aid in the success of any military operation.[11] When the quantity of materiel required to meet the human needs of armies was added to growing tonnages of ammunition and fuel, more resources had to be devoted to distribution of materiel. Without internal combustion engine powered trucks, increased logistics capabilities would not have been realized.

The second major application in the conversion of the potential energy of mechanical transport into combat power concerns tactical use. During World War I, the lorrie became so vital that governments sponsored efforts to improve

the technology. Improvements were limited as innovations such as multi-wheel drive, half-tracks, and balloon tires were too expensive for wide-scale application during or after the war.[12] Easy training and operation were so important to the British, that their government subsidized manufacturing firms to standardized controls in vehicles.[13] The driving force for most of the innovations late in the war and into the post war period was the need to increase the cross-country capabilities of the truck. Therefore, the second major application of the internal combustion engine and ground transport was to increase the tactical mobility of forces through mechanization of arms and combat units. Mobility, as defined by AR 310-15, is "the quality or capability of a military force that permits it to move from place to place while retaining the ability to perform its primary mission."[14]

After World War One, military theorists such as Fuller, Liddel-Hart, Guderian, Tukhachevsky and Triandafillov began to envision tank armies and a doctrine for mechanized formations designed for self supported cross-country movement lasting for days or weeks. This vision was fueled by the evolving technologies of the internal combustion engine and the truck.[15] They provided the actual increases while showing the potential for additional mobility for combat systems and their critical supporting assets. The development of mechanized transport paralleled the evolution of schools of maneuver warfare and doctrine in Russia, on the

Continent, and in the United States.

A detailed discussion of the development of maneuver warfare technology or doctrine is beyond the scope of this monograph. However it is important to consider how the perceived potential of mechanized transport technology affects doctrine. It is likewise important to assess the impact of increased mobility and sustainment on doctrine.

## THE IMPACT OF TRANSPORTATION AND MOBILITY ON DOCTRINE

As mentioned above, a highly mobile force is a common characteristic or governing concept of maneuver warfare of early theorists. This characteristic, in turn, affects the doctrine and design of armies. A contemporary theorist, Richard E. Simpkin, expanded the concept of mobility and identified tempo as an essential element of maneuver warfare. He described tempo as the operational rate of advance made up of seven essential elements including physical mobility and patterns of service support (logistics). These elements provided the potential energy of the maneuver force.[16] Tempo depends on physical mobility and equipment sets the upper limit on the force's mobility.[17]

Simpkin felt the helicopter would significantly increase mobility and achieve mastery over terrain.[18] However, the cost of helicopters has prevented armies from breaking their primary dependence on ground transportation.

There are two ways to increase mobility. The first

is to improve movement management in order to gain the greatest productivity from the equipment, organizations, infrastructure, and terrain supporting the maneuver force. The second is to improve the technology of trucks, trailers or other means of conveyance. Mastery of terrain begins to become possible by combining both approaches. A synergistic ground transportation system blends the right equipment with movement management.

New generations of armored vehicles and the doctrine for their employment demand a degree of cross-country mobility beyond the capability of most of the current tactical wheeled vehicle fleet.[19] The difference in rates of mobility presents commanders with planning and control problems. In trying to solve this dilemma of control and mobility, the Army has reacted with explosive growth in numbers and variety of tactical wheeled vehicles. This concerns both tactical and logistics doctrine writers as operations and movement planning has become more complex. Road networks and terrain have become so congested that additional vehicles, in fact, degrade mobility.[20]

Just as we cannot afford the ideal situation of total air mobility and resupply suggested by Simpkins, the prospect of maintaining our current fleet of wheeled vehicles has become prohibitively expensive.[21] A large percentage of vehicles have exceeded their economically useful life making them too costly to repair. Modernizing the fleet through replacing every vehicle currently in the force is

unquestionably too expensive.[22]

The Army currently experiences a quandary similar to that of armies just after WW I. Doctrine requires improvement in the mobility of combat forces and their sustaining units. But the means to this end seem today, as they did to armies after World War I, prohibitively expensive.[23]

## The Development of Containerization

Just as the internal combustion engine brought changes in the way goods were transported, the handling and distribution of goods had also changed. New machines capable of rapidly lifting greater masses of cargo replaced man and animal powered cargo handling devices. With this technology, the idea to consolidate items going to the same destination into single shipments evolved into the unitized cargo concept. Unit load devices (ULDs) are platforms designed to facilitate cargo consolidation or unitization.[24] A ULD may be as simple as a 48" x 48" wooden 'skid', as specialized as an Air Force 463L aircraft pallet, or as common as a commercial shipping container. Through substitution of heavy capital equipment such as cranes, forklifts and containers, mechanization of loading and unitized cargo resulted in reduced labor demand in both the commercial and military sectors.[25]

Unitization of cargo brought on the container revolution. Materiels handling and transportation operators

had long been allied in trying to keep cargo moving.[26] An old axiom says that goods that are not moving are warehoused and "warehousing is transportation at zero miles per hour."[27] When cargo is delayed, intrinsic inventory costs begin to accrue. Transport assets are non-productive while delayed holding inventory.

An integrated solution to circumvent delay was the development of intermodal transportation systems which permitted the interchange of freight containers between modes of transportation. Containers with compatible dimensions and handling characteristics could then be transferred between ship, truck, or air carrier without having to break the integrity of the unit load device.[28]

An early application of this interchange of containers was developed by the Bowling Green Storage and Van Company of New York for ocean movement of household goods. In the 1920's railroads began to offer a less-than-boxcar-load container service and in 1926 truck trailers were moved by rail. Larger scale applications of the concept included railcars transported on ferries and ocean-going ships.[29]

During World War II, the U.S. Navy Military Sea Transport Service employed containers, measuring six feet on each side, for small shipments on commercial vessels. Commercial transport firms used similar containers during the 1950's. But the primary application of this technology remained with the military. The Container Express Box (CONEX), a slightly larger ULD, reached the height of its use

in the mid-1960's.[30] By this time the container revolution had begun in earnest and had driven the commercial sector to use larger containers. The most common was the Twenty Foot Equivalent Unit (TEU). Other types included 24, 35, and 40 foot variants with features such as ventilation, refrigeration, half heights and open tops, as well as containers without sides called platforms and flatracks. International agreements dictated standard handling, securing, size, and exterior documentation markings. Transportation firms, port operators, government, organized labor, and most importantly, shippers forged a synergistic system to exploit the advantages incumbent in unitized movements. These advantages included increased handling and documentation efficiency, international standardization, decreased packaging, improved security, reduced cargo damage, and easier intermodal transfers resulting in quicker and more economical movement of cargo.[31]

During the 1940's and 1950's, Major General Frank Besson championed the CONEX for the Army as an intermodal ULD, moving by air, rail, or ship, finally being delivered in the cargo bed of the ubiquitous 2 1/2 ton truck. He is credited with implementing the first military container service in support of US Army units in Europe. His goal to reduce inventory costs through faster transit times established the possibility for containerization to become a significant part of modern army logistics distribution.[32] Besson, a student of logistics history, is reported to have said: "If you can

now put containerization into ammunition supply, we will finally have an improvement over the Revolutionary War."[33] Eric Rath, a transportation systems expert, writes that:

> ...the forward move of integrated transport technology via the military/civilian interchange of ideas does not go in a single, much less gradual, line of growth. Civilian cargo science must first produce and develop the next level of higher technology advance. The military will be reluctant to make further use of this development until the urgency arises.[34]

## SOLVING THE CURRENT TRANSPORTATION PROBLEM

The previous chapters have shown the evolution and military application of truck and container technology and the impact of increasing force mobility on doctrine. However, the concept for employment of military truck transportation has not changed greatly since World War I. Despite significant technical improvements, trucks still queue for loading and securing cargo when transporting sustainment or other materiel. Trucks still wait to be unloaded and are dependent on the availability of materiels handling equipment or large amounts of labor. Many trucks move only infrequently as they are platforms for mission support equipment such as command and communications instruments, special tools and logistics. These single purpose vehicles are used much like trucks early in WW I. These platforms require maintenance, present a large tactical profile, increase strategic lift requirements, and divert personnel for driving from other mission functions. They become warehouses for the systems.

The older wheeled vehicles in the tactical fleet lack

the mobility needed to sustain the tempo of the units they support. The result of demand for greater mobility has been explosive growth in the numbers of vehicles further compounding mobility problems. Units not 100% mobile shuttle equipment between locations or depend on transportation support from a central pool of trucks. Large stocks of unit spare parts and other mission materiel are carried on trailers also supported from this central pool. The size of the pool is inadequate for the doctrine it must support.[35]

The use of unit load devices has not progressed since the application of CONEXs and the 463L pallet in the Vietnam War.[36] A large proportion of cargo is still packed and shipped in small increments. Particularly for ammunition resupply, US Army use of ULDs has fallen short of General Besson's vision. With increasing dependence on commercial and host nation support for strategic and operational transportation, the solutions to transportation deficiencies have to be compatible with the current state of commercial technology.[37]

A common need has been consistently identified in each of the TRADOC Mission Area Analyses (MAA) which evaluate the Army's ability to perform its missions. This need is for a more supportable, deployable and survivable force. In the Combat and Combat Service Support MAA, ten of the top sixty deficiencies were in the critical areas of mobility and unit resupply.[38]

COL Lewis I. Jeffries establishes a useful imperative

for mobility in his article: "A Blue Print for Force Design" appearing in the August 1991 Military Review. Every unit must have the capability to move commensurate with its intended role, missions, and functions. Mobility is integral to all military organizations. But mobility assets, despite the growing numbers of tactical vehicles, are unavailable to provide all units with the same movement capability. Each unit's mobility requirement is dependent upon the mission to be performed and the time/distance factor inherent to accomplishing that mission. Organizations supporting combat units must have the same mobility of that combat unit. Units providing general support or area support can be less mobile.[39]

A solution to the weaknesses described above can be found by challenging the way the Army applies innovation to the five basic elements of the force: organization, training, leadership, doctrine, and materiel.[40] The most critical elements for solving the crisis in truck transportation are doctrine and the materiel to support doctrine.

Doctrine drives the solution. Army forces must be properly designed to implement employment doctrine. This design must include not just organizations and structures but equipment.[41] To provide unity of effort and economy of force, operational requirements must guide force structure. Units must be organized and equipped to fulfill their intended roles and implement the doctrine.[42] Therefore, unit equipment must be designed, fielded, and applied in a manner

that implements doctrine.

Doctrine should establish a set of theoretical principles to be used as a foundation for force design just as the principles of war provide a foundation for operations.[43] Current operational doctrine -- AirLand Battle, and future doctrine -- AirLand Operations, establish a clear set of principles from which a force design change may be tested. In the case of a logistics innovation, a measure of effectiveness is its contribution to the logistician's ability to apply sustainment imperatives of anticipation, integration, continuity, responsiveness, and improvisation.[44] AirLand Operations adds the concepts of proactivness, tailorablity, streamlining, and improved maintenance.[45] These concepts also serve as criteria to judge the innovation's effectiveness to amplify the logisticians capability to support doctrine.

With the proliferation of tactical wheeled vehicles, the accusation could be made that current force design lacks vision and coherence of a top down perspective. The force is designed from small unit "building blocks" upward, until end strength or budget ceilings halt the process prior to an acceptable real end state.[46] This is particularly true in logistics and support areas where forces and equipment are allocated in a building block fashion with blocks added to the force to provide initial or increased sustainment capability. Echelons are added to the structure for increased technical sufficiency, for command and control,

or based on the scope of operations or proximity to fixed facilities. Logistics or support systems are infrequently viewed from a top down perspective. This perspective is important in finding efficiencies and, more importantly, for identifying the synergistic effects of the organizational, personnel, or equipment structure.

The Palletized Load System is the materiel solution designed to address the shortfalls identified in the CSS MAA. Whether it will fit into the force structure or improve the ability of the force to execute future doctrine remains to seen. The PLS, in concept, was conceived to enhance the productivity of combat service support units, but it remains an issue still to be explored. The search for answers must begin with an examination of the features and planned application of the PLS.

## THE PLS CONCEPT

The Palletized Load System family of tactical wheeled vehicles was designed to reduce shortfalls in mobility and resupply existing across the spectrum of supporting arms. The concept for PLS specifically sought to improve mobility and increase productivity over that of the current force. It sought these improvements through standardization, pooling and minimization of vehicles, reduction in materiels handling equipment, increased distribution and surge capabilities, and enhanced force deployability.[47]

The PLS is a confluence of evolving technologies of

truck transport, materiel handling, and unitized load techniques. The British originated the military PLS concept though the technology existed with commercial waste disposal firms in the United States . The British version, called Demountable Rack Off Loading Pickup System, features the ability to handle ULDs designed for the system and standard 20 foot commercial containers. The German military developed a similar vehicle.[48] After testing the concept, the US Army initiated an accelerated procurement program for a US system.

The US Army design incorporates a 16.5 ton capacity tactical truck, a 16.5 ton capacity tactical trailer and interchangeable flatracks that serve as the cargo beds for the truck and trailer. During operations, a driver positions the truck adjacent to a PLS flatrack. The flatrack is loaded with a hydraulically powered arm or Multilift Load Handling System. Once it is lifted over the rear of the truck, it is set in position over locking devices approved by the International Organization for Standardization (ISO) securing it to the frame of the truck (See illustrations at Appendix A). The flatracks meet ISO standards for commercial containers and can be transported by military semitrailers as well as commercial chassis. The flatracks are compatible with British and German versions of the PLS.

The fielded PLS will come in two configurations. One will support unit level ammunition handling in Field Artillery units and one will conduct Class V resupply mis-

sions for Ordnance and Transportation units. PLS trucks assigned to Field Artillery units will have a Material Handling Crane (MHC) integral to the truck permitting partial discharge or trans-loading of cargo on the flatrack. The version assigned to combat service support units will not have this crane.[49]

Oshkosh Corporation holds an initial low rate production contract for approximately 2700 PLS trucks and trailers. These vehicles, with flatracks, will each cost approximately $278,000; the additional 11,000 flatracks, needed to complete the initial system, will cost about $5700 each.

Given its capabilities, its ability to contribute to execution of doctrine is limited not by a technical shortcoming but restriction on its planned use. The PLS was conceived as a system to be integrated throughout the force structure to increase logistic capabilities while minimizing vehicles in support units and maintaining unit mobility.[50] Branch schools and Combined Arms Support Command have identified other potential applications for the PLS. They include use in Deployable Medical Systems (DEPMEDS), divisional repair parts, and bulk Class III (POL) distribution.[51] For now however, the system has been procured for and restricted to use in ammunition distribution operations.[52]

## THE MOADS/PLS APPLICATION

The primary application for the Palletized Load System is support of the Maneuver Oriented Ammunition Distribution System (MOADS). This structure is the foundation for munitions support for current doctrine. This is the only part of doctrine currently scheduled to be supported by the PLS.

The concept for ammunition support prior to MOADS was based on supply point distribution requiring redundant material handling equipment (MHE) at Corps Storage Areas (CSAs), Ammunition Supply Points (ASPs) and Ammunition Transfer Points (ATPs). This vulnerable and inflexible system was characterized by large stockpiles of ammunition grounded in supply points with long lines of trucks waiting to deliver or pick up stocks.[53]

MOADS emphasizes throughput of combat configured loads to divisional supply points. It adds a third ASP for each division further dispersing one to three days of ammunition supply. With a reduced tactical signature and increased flexibility, MOADS better supports both defensive and offensive operations.[54]

MOADS does not eliminate the requirement to handle considerable volumes of ammunition packaged in relatively small increments. Ammunition distribution continues to depend on wooden pallets or skids stored on the ground in supply areas or on prepositioned trailers. Additional rehandling of these pallets or delays while ammunition supply units wait

for trailers require more extensive use of limited MHE and result in less efficient use of transportation assets. Both rehandling and transportation delays add to processing time at the ammunition supply point.

At the delivery point, ammunition vehicles wait to unload or for trailer transfer. With good timing, the delivering tractor can hook up to an empty trailer and return for the next load. If timing is bad, the tractor either waits for a trailer, effectively removing the tractor from the distribution system for this cycle. If the tractor returns without a trailer, that trailer is eliminated from the distribution system until it later can be retrieved.

When the PLS is fielded MOADS will become MOADS/PLS. Under this doctrine, stocks will be stored and transported on flatracks with single types of ammunition or on flatracks with combat configured loads (CCLs). CCLs are composite loads of ammunition commodities, such as projectiles, propellant charges, fuses, primers, and various types of small arms ordnance (See example CCLs at appendix B). Combat Configured Loads reduce administration and handling during transfer operations at the supply point and more importantly at the point ammunition is transferred to a unit.

Under MOADS/PLS, the ordnance unit no longer uses its MHE to load or unload trucks as it takes advantage of the ability of PLS trucks to load or unload larger ULDs of ammunition. Instead, it allows ammunition supply units to concentrate MHE on organizing and loading flatracks containing

CCLs anticipating or responding to unit Class V forecasts. The capability of the PLS truck to load and unload rapidly improves both the productivity of the ordnance unit and of transportation units used to distribute ammunition.[55]

The operational concept for MOADS/PLS is based on a continuous ammunition refill system with distribution to ATPs or ASPs in the Division rear or ASPs in forward positions in the Corps Area.[56] All ammunition received from the Theater Support Area (TSA) or directly from a port, is configured by DODIC (Department of Defense Identity Code). Under MOADS, the unit operating the Theater Support Area ships ammunition to the Corps Storage Areas and Ammunition Supply Points. Under MOADS/PLS, the TSA ships only to the CSA. Ammunition is stored by commodity on PLS flatracks and these ULDs are shipped forward on theater line haul trailers or rail flatcars for delivery to the Corps Storage Area. 50 % of the CSA stocks will be received on flatracks from the Theater Storage Area; the balance comes in containers directly from the port. With division forecasts and updated requirements, the Corps Storage Area builds combat configured loads and ships them forward.[57]

To meet surge requirements or to compensate for interruption of lines of communications, ASPs continue to stock 1-3 days of supply (See diagrams of MOADS and MOADS/PLS at Appendix C).[58] Munitions are delivered forward on PLS vehicles from CSAs and ASPs to the ATPs or battalion trains for artillery, armor, aviation, and infantry units. Field Ar-

tillery units with PLS capability will return empty flatracks and pick up loaded ones. Other stocks will be transferred using on-board cranes integral to unit ammunition trucks or by the Class V section of the supply platoon of the Forward Support Battalion Supply Company.[59]

Recycling of empty flatracks in the distribution system begins at the time of delivery. However, PLS flatracks are stackable. Transportation units can recover them later and achieve greater productivity over the one for one tractor to trailer ratio experienced in recovering semitrailers.[60]

In summary, through the integration of improved truck technology with materiels handling capability and application of unitized load principles, the PLS streamlines ammunition distribution. It achieves throughput of close to 100% of Class V resupply to battalion field trains with Combat Configured Loads. Forecast benefits also include reducing ammunition concentrations in Brigade Support Areas, diminishing queues associated with ammunition transshipment operations, further dispersion of ammunition stocks, and increased mobility of ATPs and ASPs. CCL configuration efforts will shift back to relatively more secure CSAs. The enhanced tempo possible under PLS/MOADS will increase the ability of transportation and ordnance units as well as the support structure within combat formations to more rapidly adjust to changing tactical situations.[61] This, in turn, potentially makes ammunition supply more responsive to doctrine.

Additionally, MOADS/PLS will save an estimated $600 million in heavy truck fleet life-cycle costs by elimination of 3900 trucks, trailers, and pieces of materiel handling equipment and permit reduction of 3600 personnel positions dedicated to Class V distribution. The PLS is expected to provide an opportunity to shift 2700 HEMMTS, 1200- 5 ton tractors and 3000 trailers into other missions allowing these assets to support other mobility requirements.[62]

The introduction of PLS technology and MOADS/PLS will fundamentally reshape ammunition resupply. This is an essential sustainment function to modern mobile armies. As portions of the force are being redesigned to accept this innovation, it is now important to apply imperatives from doctrine to assess the implications of this technology.

## IMPLICATIONS FOR AIRLAND BATTLE

Jomini concluded that there were twelve essential conditions necessary for making a perfect army. Among these are armaments superior to that of the enemy and a staff capable of applying these arms.[63] The PLS can be considered a Jominian armament and its application the test of the staff's ability to derive the greatest combat power from its employment. The PLS must be assessed to determine whether its intrinsic capabilities will allow users to better execute both current and future doctrine. The doctrine of Airland Battle requires the logistician to fulfill the imperatives

of anticipation, integration, continuity, responsiveness and improvisation. The PLS must, therefore, substantially contribute to the logistician's ability in this effort.

<u>Anticipation</u> of logistics requirements is key to the ability of a force to seize or retain the initiative and its ability to conduct synchronized operations. Anticipation is more than the ability to make a good guess of what will be required. It is taking action to maintain or accumulate the assets necessary to support the commander's intent throughout an operation, even should it change.[64]

Flexibility is required to shift logistics effort or rapidly change the direction of support. At the tactical level, actions may require rapid readjustment of basic loads, increases in resupply rates, or a shift in priority of support from one unit to another. Anticipation prevents shortages of fuel, ammunition, parts, or services that limit a unit's ability to react to changing tactical situations.[65] In summary, anticipation demands that the logistician preposition resources forward, in expectation of requirements rather than in reaction to them. Logistics support must allow the tactical commander to hit the window of tactical opportunity before it is closed and the probability of battlefield success is diminished.[66]

The PLS, and its initial application in MOADS, significantly contributes to the ability of logisticians to anticipate. It will increase the mobility of ammunition stocks within storage areas. It capitalizes on potential for expand-

ing the use of combat configured loads and provides more rapid distribution by use of this unit load device concept.

PLS flatracks, as sideless containers, exploit the advantages of efficiency and speed that a unit load device provides over ammunition shipments normally moving in small pre-packaged quantities. This increases the ammunition supply unit's lift capability. Stocks configured on PLS flatracks are easy to disperse within the storage area because fewer lifts are required per ton of ammunition. This factor also increases the displacement speed of the entire storage area if threatened or ordered to relocate during offensive operations.

Though trailer transfer techniques have made efficient use of semitrailers, the replacement of trailers by more numerous and flexible flatracks is expected to eliminate delays incurred during trailer loading. By prepositioning and efficient turnaround of empty flatracks, the ammunition supply unit can build unit configured loads before transportation arrives. Ammunition units can increase productivity by devoting manpower and materiel handling equipment to loading flatracks. They will exert better control over production scheduling than when it was dictated by trailer availability.

The use of trailers as both conveyance and platform for cargo unitization is inefficient. Conveyances that are delayed waiting to load, that lose time being loaded and secured, or that are loaded but waiting for a tractor, have become

warehouse devices -- 'transportation at zero miles an hour.' Commercial transportation firms use a planning ratio of containers to trailer chassis of at least four containers to each chassis. This provides them with the most efficient use of chassis.[67] The PLS with its flatracks approaches this ratio so that vehicles and trailers are not delayed by loading operations. The resulting gain in effecient use of transportation assets is a gain in capablity. With increased capability, there is corresponding gain in the ability to accumulate resources in anticipation of changing situations. Therefore, the PLS greatly improves the ability of logisticians to anticipate demands for ammunition distribution.

However, with the limited procurement of the PLS and a force design supporting only ammunition distribution, the Army loses the synergistic effect of a multipurpose distribution platform.[68] Because the PLS is not to be used to distribute other classes of supply, logisticians lose flexibility and some of the ability that the PLS would give them to meet the requirements of the anticipation imperative.

<u>Integration</u> of combat service support into every phase of a tactical operation is essential to success. Support unit commanders must plan support operations to meet the intent and complement the tempo set by the combat commander. This gives the tactical commander the greatest freedom of action.[69]

The PLS, by increasing speed of ammunition resupply, permits the logistician to better integrate this sustainment function into tactical plans. This labor intensive and awkward task now begins to become elegantly simple. Not only are truck turn around times in ammunition storage areas reduced by rapid loading and transfers to units faster, but the enhanced mobility of the PLS allows it to keep up with maneuver elements and reach locations previously impossible for delivery by tractors with semitrailers.

With rapid self-unloading, the delivery process creates less tactical signature as the non-unit transport assets depart promptly. Supported units pick up cargo almost instantaneously without time consuming rehandling or cross-loading. The PLS facilitates the use of the cache concept. Loads are easier to conceal due to lower signatures. The PLS also hastens the placement of caches and accomplishes this without having to expose valuable trailer assets. The effect of all these improvements is that use of the PLS allows logisticians greater options in integrating ammunition resupply into fast moving or rapidly changing tactical operations.

The continuity imperative implies much more than the concept that logistics support must occur continuously; it compels the logistician, due to the nature of AirLand Battle, to exploit every opportunity to replenish the combat force. The battlefield envisioned by the writers of AirLand Battle doctrine varies in intensity and is characterized by periods of activity that correspond to efforts by both oppo-

nents to rebuild units and bases of support.[70] The PLS contributes to generating speed and mass for support forces which will shorten the periods of operational inactivity.

The ultimate goal is to eliminate the pauses that result from the inability of combat service support units to maintain the tempo of Airland Battle. A pause for replenishment, no matter how brief, robs the tactical commander of momentum and probably the initiative as well.[71] The PLS will increase the ability of combat service support units to keep up with the maneuvering force through increased mobility as well as cargo capacity. Rapid resupply or cache operations combined with enhanced push packages of unit configured loads reduce handling time by the supported unit and could evolve into a resupply on the move concept for ammunition.

Continuity also requires that sustainment efforts do not become hostage to a single line of communication or mode of transportation.[72] Logisticians retain flexibility with the PLS as it is not as dependent on a road network as the tractors and semitrailers that have previously been used to move ammunition. The PLS incorporates central tire inflation technology to greatly reduce debilitating effects of waterlogged or desert terrain.

Flatracks can be transported on military semitrailers, on commercial container chassis, on railroads using container on flatcar equipment, or on inland waterway barges with standard locking devices. These multimodal characteristics reduce the risk and impact when a segment or a mode of the LOC is

interrupted through the actions of the enemy or by acts of nature. With the PLS, logisticians can ensure greater continuity which allows operations to achieve greater depth and tempo with less risk to both momentum and initiative.

<u>Responsiveness</u> is the ability of the support system to react rapidly to changes in requirements or in the direction of sustainment.[73] This capability is critical to AirLand Battle doctrine as combat forces are called upon to exploit fleeting opportunities on short notice.[74] For logisticians this is a function of speed, volume, agility, and access. Reaction time to a changed requirement must be quick and the response must include the volume of sustainment required to meet the needs of the tactical commanders. The need to surge is tempered in AirLand Battle logistics doctrine by strong forward support. It emphasizes unit forecasts over requisitions for distribution of high-volume, fast-moving commodities.[75] Carefully programed logistics movements are constrained by limited truck assets dedicated to a particular commodity. The requirement to surge and change movement support is difficult. It can significantly affect other aspects of the operation. Access is the final characteristic of responsiveness. Materiel or services must physically reach the supported unit in time for the commander to seize his opportunity.

Consider again the characteristics of responsiveness, speed, volume, agility and access. With improved turn around time in ammunition supply points and at the point of

delivery, the PLS increases both the speed and volume of surge operations. It gives the logistics structure increased capability for the ammunition system to surge with less impact on other supply distribution. Likewise, agility is enhanced by time saved when replacing one load for another of a higher priority. The PLS' improved mobility over the tractor and semitrailer gives the logistics system greater access forward and reduces the vulnerability of the transfer site by rapid clearance of the area.

**Improvisation**, the final imperative of AirLand Battle sustainment doctrine, is the most difficult to grasp as it is sometimes substituted for anticipation rather than used as a complement to it. CSS planners and operators must be able to adapt to unique situations and unanticipated events that require suspension of normal procedures, techniques and practices. They must possess a vision that focuses on unusual sources of supply, transportation, and innovative uses of material and techniques.[76]

The current purchase and distribution plan for the Palletized Load System limits its use to ammunition distribution. Because the system is not fielded across the spectrum of army units, the opportunity for improvised application is constrained. This does not mean that impromptu and innovative uses are not possible, only that the decisions to implement them are more difficult because diversions of the PLS vehicles will degrade ammunition resupply.

As mentioned earlier, there has been effort to

develop applications for the Palletized Load System beyond the imperative of battlefield improvisation. In order to explore gains in the productivity, agility, and mobility of the PLS, Combined Arms Support Command (CASCOM), TRADOC schools and other technical centers have begun searching for further applications.[77]

The results from this effort will come too late for integration of the system into current AirLand Battle doctrine. It does have poter.·ial for emerging AirLand Operations doctrine and its enabling logistics concepts of proactivness, tailorablity, streamlining, and improved maintenance.

## IMPLICATIONS FOR AIRLAND OPERATIONS AND THE FUTURE

Changes in technology, equipment, or force design must also be tested to assure utility in future doctrine. AirLand Operations (ALO) concepts are now being evaluated as the evolving doctrine for a strategic army in the 1990's. This emerging doctrine is built upon and refocuses the concepts and capabilities governing the forces that had executed ALB.[78] The sustainment imperatives we have examined are as valid for emerging doctrine as they are for current doctrine.

ALO focuses on a changing environment, seeking to exploit advantages of emergent and superior applied technologies as well as nonlinear operations to dictate terms of battle to an enemy. It seeks to avoid mutual attrition,

high density war, and lengthy campaigns that have been characteristic of Central Europe.[79] In assessing the potential of the PLS to amplify the efforts of ALO logisticians, it is important to briefly examine its enabling logistics concepts and the ways PLS technology might be applied.

ALO calls for proactive logistics command and control systems. These give CSS commanders the ability to read the battlefield in real time to maintain logistics tempo commensurate with extended operations of more intense tactical tempo. Logistics units must be tailored into multifunctional organizations configured to the tactical situation and focused for the duration of the combat operations.[80]

The streamlining concept requires unit distribution to sequence specially configured supplies and services directly to the lowest tactical level practicable. The distribution system must be flexible so that the movement of sustainment materiel can by-pass echelons of support and go directly to maneuver units or even key combat systems. Improving maintenance implies not only rapid diagnostics and recovery, but streamlining repair parts supply to enhance unit mobility without degrading responsiveness.[81]

In transportation and distribution, these concepts have spurred requirements to project support forward through the depth of the battlefield in mobile operations through the detection, fires, maneuver, and recovery phases of ALO.[82] The ALO concept places emphasis on the

Forward Support Battalion and Corps logistics structure to unweight the maneuver commander and facilitate extended offensive operations conducted by brigade sized forces. Complementing this scheme of maneuver, real time logistics and supply in motion will provide sustainment directly from Corps to Forward Support Battalions coordinated through the Division Support Command.[83]

Transportation companies in multifunctional Corps Support Battalions assigned to Corps Support Groups will accomplish the primary transportation mission. Their trucks will be used in continuous, controlled movement focused on throughput distribution. The Transportation Motor Transport Company, currently in the Main Support Battalion, will be eliminated under one proposal and Combat Transportation Companies (CTCs) will be organized in each FSB with vehicles currently assigned to the maneuver units and the TMT company. The CTC will provide distribution and movement support to brigades.[84]

From this brief analysis of ALO transportation and distribution doctrine, it is apparent that the MOADS/PLS concept can complement ALO with its inherent mobility and responsivness. However, limiting the PLS to ammunition distribution does not take full advantage of its unitized load capabilities and integrated ground mobility and materiel handling technology. The Army would not be leveraging all the potential of existing technology and it would fall short of achieving a synergistic ground transportation sys-

tem suited to support ALO.

The search for synergistic application of PLS for ALO begins with expanding roles for the system. Class III (bulk fuel) is a potential candidate. The PLS can not only replace some current distribution assets but also servicing equipment to improve fuel resupply. PLS flatracks with three 900 gallon pods or a 3500 gallon "bag in a box" proved to decrease displacement times and increase throughput of POL supply units.[85] The PLS would accentuate the cache concept for fuel in the same way it will for ammunition supply. However, modified commercial tank containers with integrated pumps should be considered over the options mentioned. These could replace 10,000 gallon bladders in fuel system supply points. They would provide greater protection compared to the soft fabric bags, permit quicker site preparation, increase delivery rates, and allow for movement of partially empty units which is not possible with partially filled bags. These tank containers are internationally compatible and by virtue of their multimodal characteristics, offer more flexibility to transportation planners as alternatives to 5000 gallon tankers. Strategic movement of this fuel unit load device via container ships will save space on critically short roll-on roll-off vessels and, if moved loaded, will provide immediate fuel stocks in contingency operations.

The PLS has potential application in all direct support and general support maintenance units which, along with ac-

companying stocks of repair parts, have been relatively immobile. Studies conducted by the Ordnance Center show that these units can achieve the same or better mobility through use of flatrack mounted shelters while reducing the number of vehicles in the unit.[86] Work shops, parts storage, special tools and test kits, power generation, and administrative shelters would be ISO/PLS compatible and transportable via any mode capable of moving a standard container. This will achieve enhanced tactical mobility, more flexible strategic mobility, and reduce the extensive maintenance effort at unit level as trailers and trucks are eliminated. There would also be gains in work efficiency and protection as these facilities and stocks would sit near ground level with easier access and reduced tactical signature.

Just as with ground maintenance units, the PLS offers advantages of improved mobility, flexibility, and capabilities to aviation maintenance units .[87] The PLS would make possible more robust and capable maintenance facilities at FARP sites co-located with flatrack mounted aviation UCLs of ammunition and fuel.

Deployable Medical Systems (DEPMEDS) hospital units currently plan to use ISO compatible shelters and tents. Other equipment and supplies will be carried in standard containers. Testing of this concept proved that tactical and strategic mobility were less than adequate.[88] With these facilities integrated into PLS compatible platforms, DEPMEDS is expected to achieve time savings in unit displacement and

vehicle maintenance increasing the hours available for medical treatment.[89] This additional mobility and flexibility will allow the tactical planner greater availability of medical support.

Emerging innovations such as Ground Positioning Systems, miniaturized short distance radio transmitters and Microcircuit Technology in Logistics Applications will foster revolutionary improvements in logistics management when incorporated with the PLS. This merging of technologies will yield more accurate, timely, and responsive movements management thus expanding the capabilities and efficient use of transportation assets.

With increased capabilities come new techniques for support operations. The cache method, discussed earlier, can be more sophisticated. Maneuver units, following the signal of a miniature transmitter, will locate multiple commodity flatracks prepositioned at pre-planned points using GPS. Another variation might be a floating supply point or "wagon train" moving from position to position.[90] Once a maneuver commander has chosen a resupply point based on METT-T, the PLS trucks and trailers are capable of moving to that point to meet the unit or drop the flatracks prior to unit arrival. Empty flatracks would be recovered later. This inventory-in-motion concept adds to the passive protection posture of all logistics forces as greater dispersion and more frequent moves become possible.[91]

The potential gains for increasing logistics power

through the PLS are not solely restricted to those mentioned above. However, to achieve synergy for ALO, a fully integrated truck fleet must be fielded in all units, not just in selected combat service support elements and combat support arms. The PLS is too expensive to replace all medium and heavy vehicles in tactical units.[92] Therefore, HEMMTs continue to be an effective support vehicle for armor and mechanized units.

However, the PLS can reduce the number of vehicles in these units while expanding movement capability. For example, the field trains of an armor battalion has a mixture of 37 trucks and five trailers with cargo capacity of 179 STs, 8803 cu ft and 40,500 gallons of fuel. By replacing these with 13 PLS trucks and trailers (16 fuel flatracks @ 2700 gal each and 10 cargo flatracks) the unit improves cargo capacity to 246 STs, 9714 cu. ft., and 43,200 gallons of fuel. Similar gains are possible in mechanized infantry units.[93]

Reducing numbers of vehicles while maintaining cargo capacity and materiels handling capability would benefit the light infantry division in AirLand Operations. The unprecedented flexibility of the PLS would allow it to deploy with nearly the same strategic lift requirements but have greater mobility for employment and increased staying power due to more efficient resupply operations.[94] The overall effect of replacing these vehicles with PLS will be enhanced organic support for units conducting ALO extended

offensive or deep operations.

The critical point of leverage for AirLand Operations on PLS technology lies in achieving synergy through not only applying the PLS across the spectrum of logistics but for improving tactical and strategic mobility of all units. With the PLS, it is possible to standardize types and decrease numbers of vehicles eliminating some of the planning, space and control problems associated with differences in mobility of the force and battlefield congestion.

Just as commercial industry has modified containers to accept increasing varieties of cargo, the PLS flatrack can be modified into a platform for command and control, logistics or other mission support functions. Any unit less than 100% mobile and any towed or truck mounted system remaining stationary for significant periods of time offers possibilities for unitization on a PLS platform. This concept goes beyond simply mounting systems on flatracks. Future system designs should incorporate features permitting them to be directly lifted and secured to the PLS truck and trailer. In this way, larger portions of the force acquire the increased mobility attainable through the integrated technologies of the PLS. The elimination of vehicles and trailers will reduce maintenance requirements for mounted and ease battlefield congestion. The manpower once devoted to maintaining the vehicle portion of systems is directed back into mission performance.

Achieving this synergy between mobility, sustainment,

and mission enhancement is key to fulfilling the potential of the Palletized Load System for AirLand Operations. At this point logisticians will find themselves better able to apply the concepts of proactiveness, tailoribility, streamlining and improved maintenance.

## CONCLUSIONS

The Palletized Load System is the integration of convergent technological developments accumulated over the past 100 years. Advances in truck transportation, in materiel handling equipment, and in unitized cargo loading have been propelled by demand for efficient operations in the business sector. The military use of innovations in these fields has been both a stimulus for and stimulated by doctrine demanding improved mobility and sophisticated sustainment. As these technologies have afforded greater efficiencies in the commercial arena, they offer even bigger productivity improvements for the military. They extend beyond the transportation and distribution functions common to both logistics structures.

PLS technology will enable force designers to meet unique military equipment requirements for tactical mobility and sustainment demanded by current and future doctrine. The PLS is the platform that will improve the strategic mobility as well as operational and tactical movements of supplies in AirLand Battle. With potential to improve

mobility for all parts of the force, it will increase the effectiveness, speed, security, and integration of unit actions in AirLand Operations.

COL Lewis I. Jeffries writes that, "If the Army as a whole is not designed to achieve as much synergism as possible, its forces will not be able to return the 'biggest bang for the buck' and more ominously, may not be able to fulfill its strategic role."[95] The PLS is capable of providing that synergy for mobility and sustainment across the force. It can not do it now as it is a single application vehicle supporting primarily field artillery ammunition distribution in the same way that the British used the lorrie in the early stages of World War I. As discussed, the evolving doctrine will require multiple, integrated and synergistic application of the PLS.

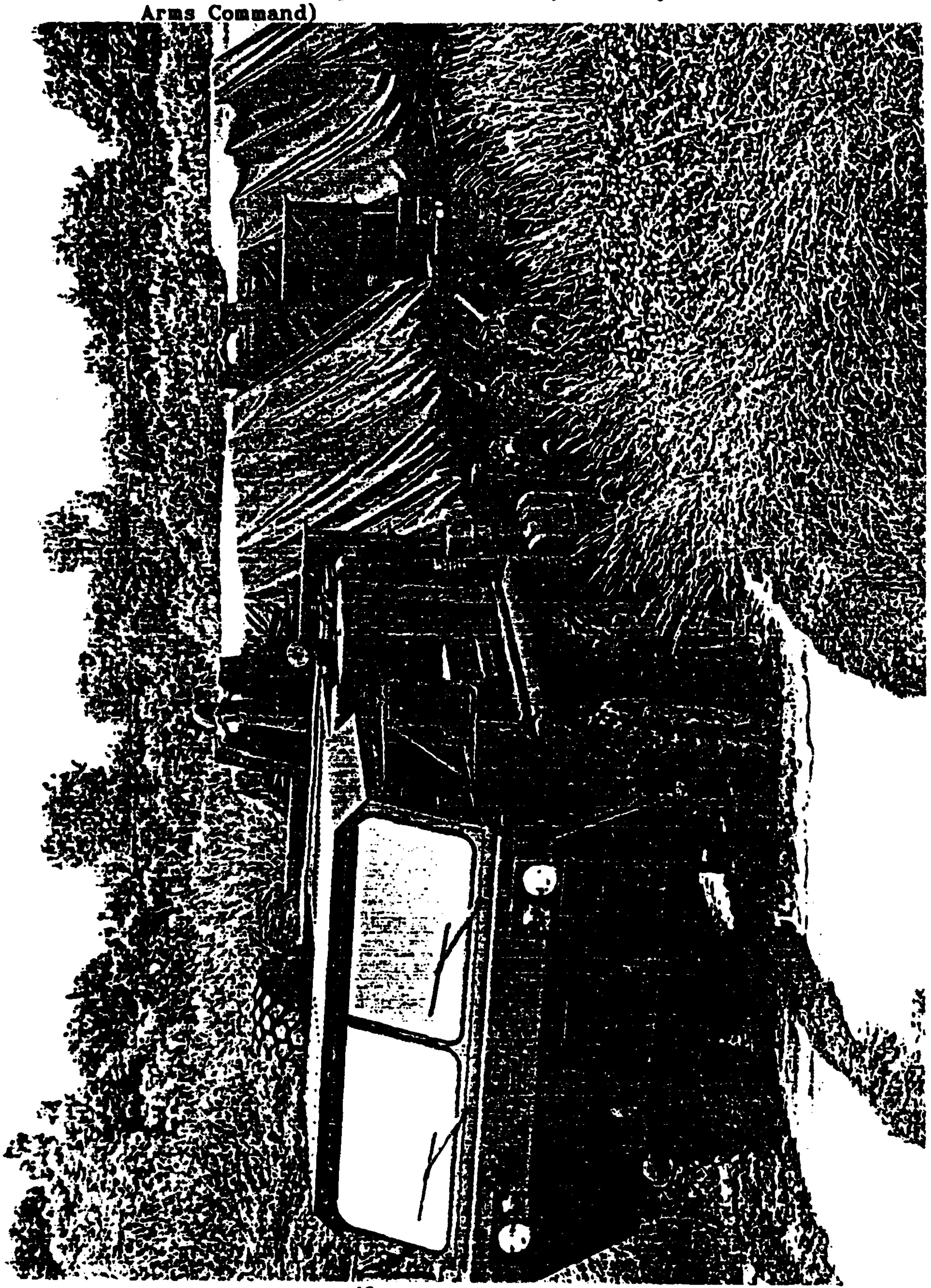
Simpkin observes that the pattern of military innovation is one where there is a radical change in equipment, doctrine, or force structure. A gestation period of between 30 and 50 years or more can be found between technology becoming feasible, or the need for the change apparent, and full scale adoption of the innovation.[96]

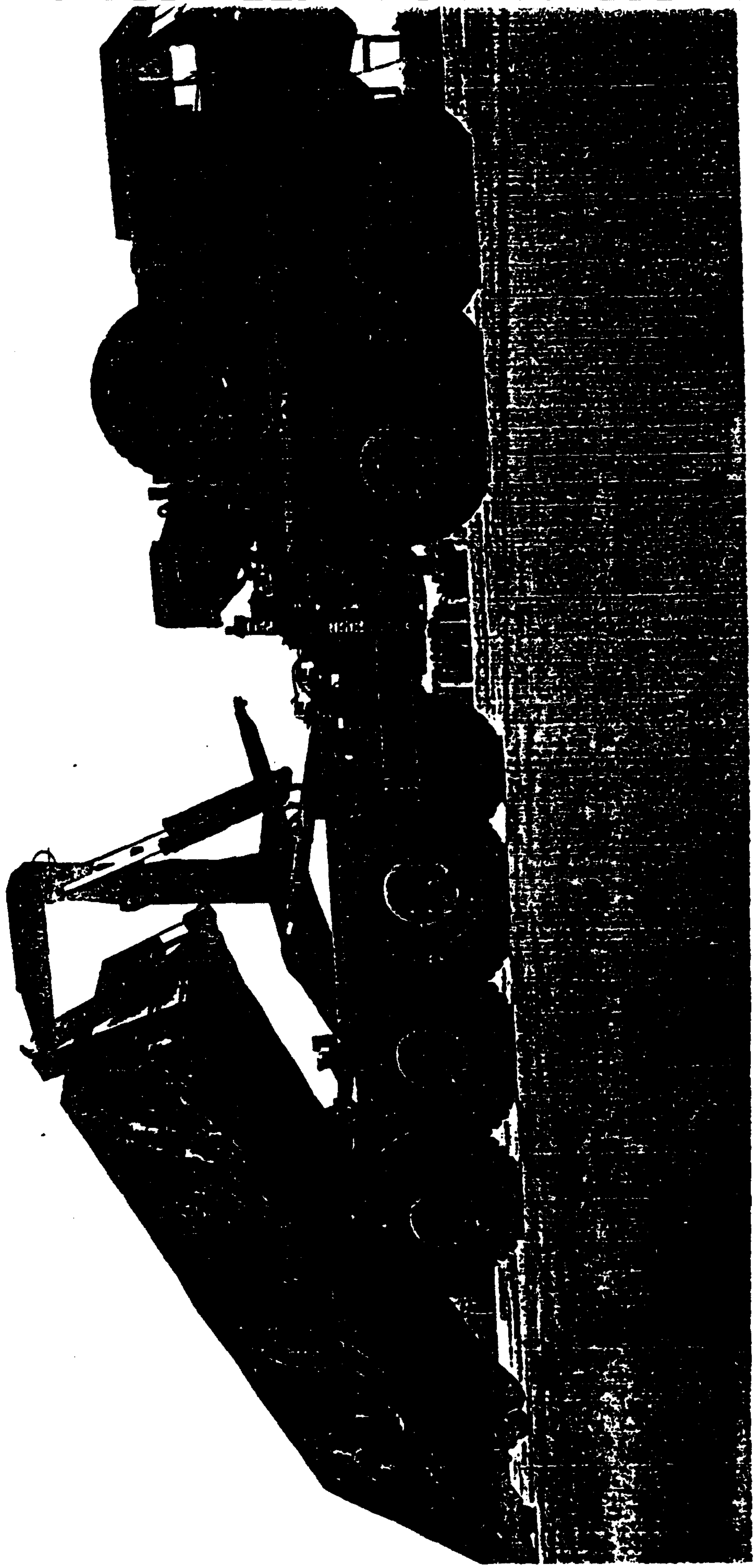
This pattern can be broken; the technology is at hand. A new, demanding doctrine calls for increased capabilities that can be provided by the technology. The changing force structure, defense budget, and strategic reality have increased risk by dictating heavy dependence on commercial, allied or host nation support for deployment and movement.

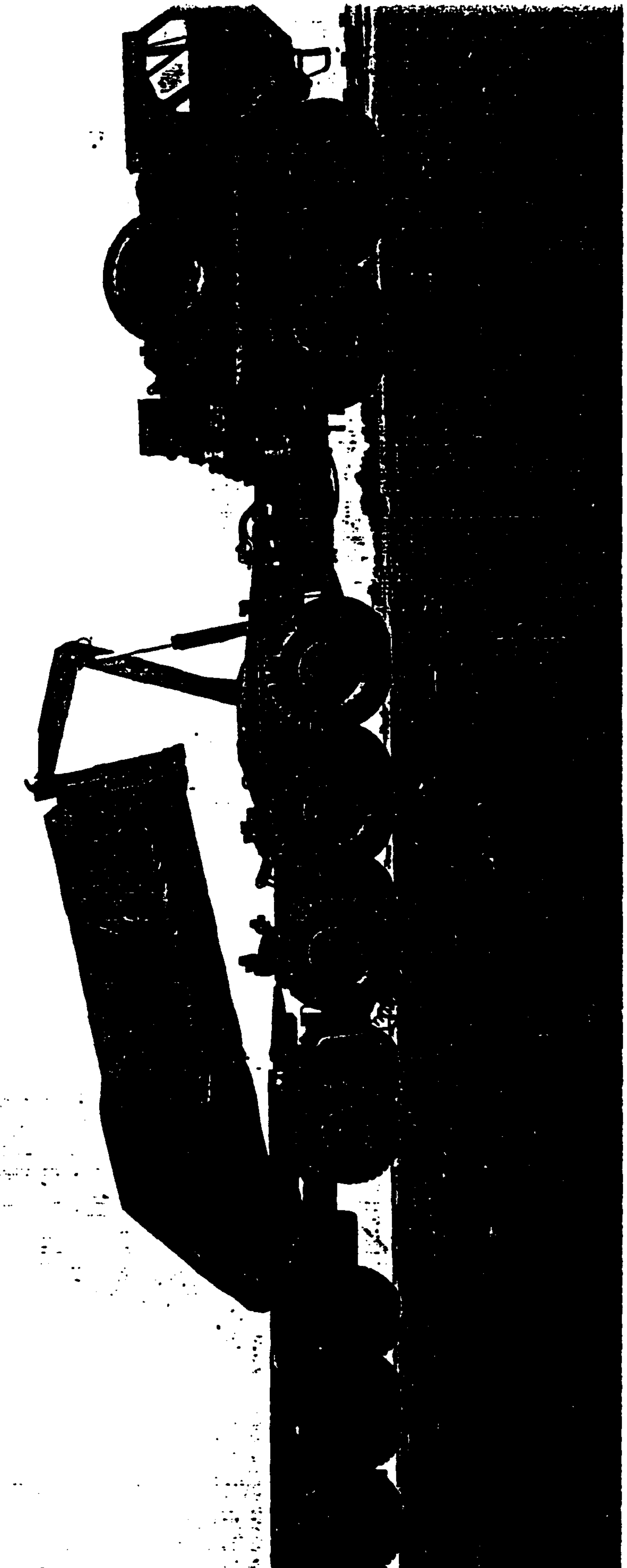
Reduction in force size as well as conversion from a forward deployed to CONUS based force projection strategy compounds this risk. Once it can be deployed to the AirLand Operations battlefield, the twin liabilities of nearly unmanageable numbers of tactical wheeled vehicles congesting the battlefield and an aging, relatively immobile, and hard to maintain truck fleet strains and threatens the effectiveness of the force.

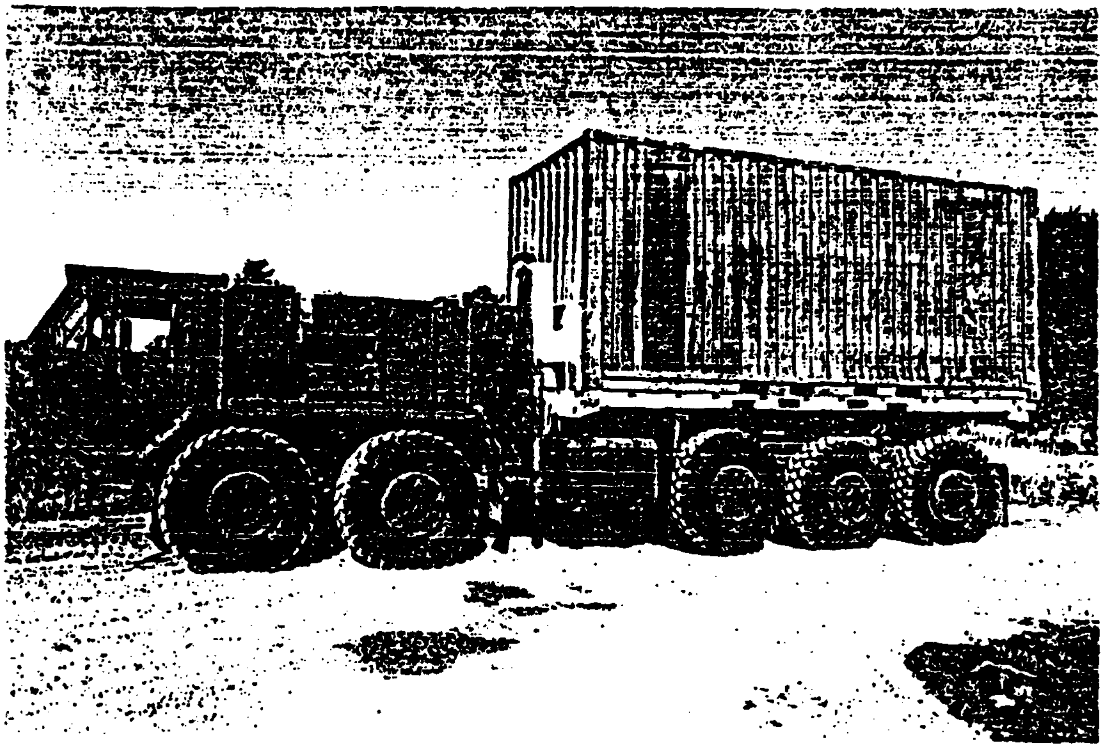
The Palletized Load System can not be considered a panacea nor should it enter the force structure as an invisible technology. By challenging old ways of doing business and force design, it can offer integrated synergistic solutions to challenges that begin at home station and the factory gate and do not cease until consolidation at the objective on a distant battlefield.

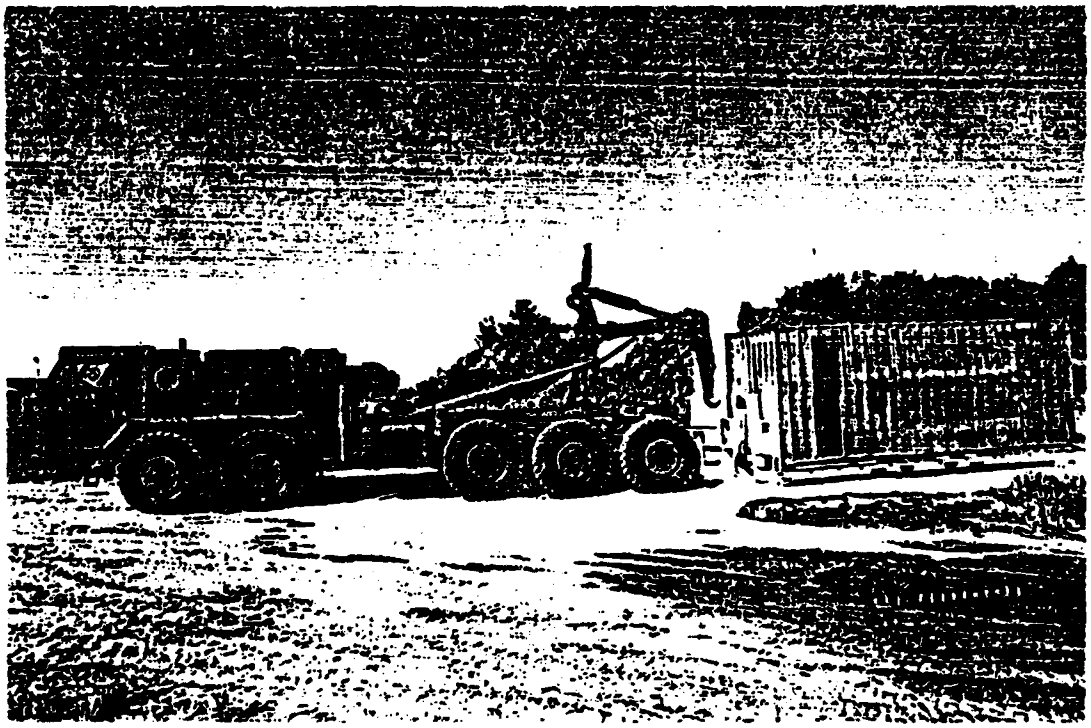
Appendix A: Photographs of Palletized Load System. (From the files of Combat Developments Directorate, US Army Combined Arms Command)











## Appendix B: Diagrams of Combat Configured Loads on Palletized Load System Flatracks. (From files of Combat Developments Directorate, US Army Combined Arms Command.)

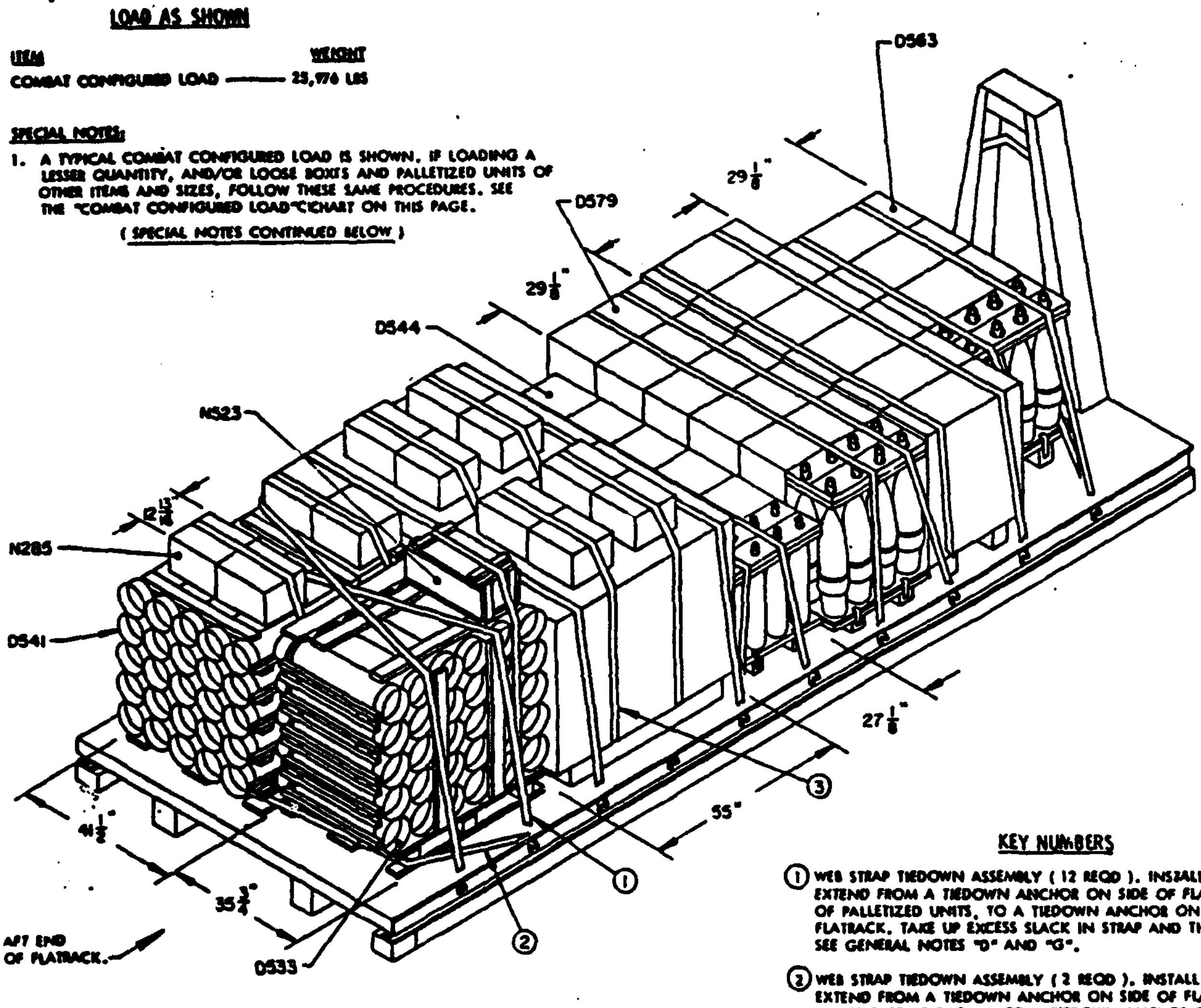
**LOAD AS SHOWN**

| ITEM | WEIGHT |
| --- | --- |
| COMBAT CONFIGURED LOAD | 25,976 LBS |

**SPECIAL NOTES:**

1. A TYPICAL COMBAT CONFIGURED LOAD IS SHOWN. IF LOADING A LESSER QUANTITY, AND/OR LOOSE BOXES AND PALLETIZED UNITS OF OTHER ITEMS AND SIZES, FOLLOW THESE SAME PROCEDURES. SEE THE "COMBAT CONFIGURED LOAD" CHART ON THIS PAGE.

( SPECIAL NOTES CONTINUED BELOW )




**ISOMETRIC VIEW**

( SPECIAL NOTES CONTINUED )

2. WHEN LOADING FLATRACK, CENTER THE REAR TWO PALLETS ACROSS THE WIDTH OF THE FLATRACK, AND CENTER LONGITUDINALLY BETWEEN THE TWO TIEDOWN ANCHORS TO WHICH STRAPS MARKED ① WILL BE ATTACHED. POSITION ALL OTHER PALLETIZED UNITS TIGHT AGAINST THE REAR TWO AND EACH OTHER, LATERALLY AND LONGITUDINALLY.

3. WHEN LOADING LOOSE BOXES ON TOP OF PALLETIZED UNITS FOLLOW THE PROCEDURES IN KEY NUMBER ③ .

4. A TOTAL OF TWENTY-ONE ( 21 ) WEB STRAP TIEDOWN ASSEMBLIES ARE REQUIRED FOR THE LOAD SHOWN.

**KEY NUMBERS**

① WEB STRAP TIEDOWN ASSEMBLY ( 12 REQD ). INSTALL EACH STRAP TO EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF FLATRACK, OVER TOP OF PALLETIZED UNITS, TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF FLATRACK. TAKE UP EXCESS SLACK IN STRAP AND THEN RATCHET TIGHT. SEE GENERAL NOTES "D" AND "G".

② WEB STRAP TIEDOWN ASSEMBLY ( 2 REQD ). INSTALL EACH STRAP TO EX EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF FLATRACK, AROUND PALLET BASE AS SHOWN, TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF FLATRACK. TAKE UP EXCESS SLACK IN STRAP AND THEN RATCHET TIGHT. SEE GENERAL NOTES "C" AND "D".

③ WEB STRAP TIEDOWN ASSEMBLY ( 7 REQD ). PRE-POSITION EACH STRAP UNDER TOP DECK OF PALLET, AT LOCATION DESIRED, PRIOR TO POSITIONING PALLETS TIGHT AGAINST EACH OTHER. POSITION LOOSE BOXES ON TOP OF THE PALLETIZED UNITS. BRING ENDS OF STRAP MARKED ③ UP OVER TOP OF LOOSE BOXE ( S ) AND HOOK ENDS OF STRAP TOGETHER. TAKE UP EXCESS SLACK IN STRAPS AND RATCHET TIGHT.

**COMBAT CONFIGURED LOAD**

| DODIC | ITEM | DIM ( INCHES ) | WEIGHT POUNDS | QUANTITY |
| --- | --- | --- | --- | --- |
| D533 | PROP CHG, 155MM, RBG M119 | 35-3/4" X 52-1/2" X 49" | 1,452 | 1-PLT |
| D541 | PROP CHG, 155MM, WB, M4 | 41-1/2" X 35" X 45-7/8" | 1,751 | 3-PLTS |
| D544 | PROJ, 155MM, HE, M107 | 13-5/8" X 27-1/8" X 30" | 797 | 6-PLTS |
| D563 | PROJ, 155MM, ICM, M483 | 14-5/8" X 29-1/8" X 39-3/8" | 874 | 10-PLTS |
| D579 | PROJ, 155MM, RAP, M549 | 14-5/8" X 29-1/8" X 38-3/4" | 830 | 6-PLTS |
| N285 | FUZE, MTSQ, M577 | 8-9/16" X 14-5/8" X 12-13/16" | 60 | 12-BXS |
| N523 | PERCUSSION PRIMER, M82 | 11-1/4" X 12" X 24-1/8" | 49 | 1-BX |

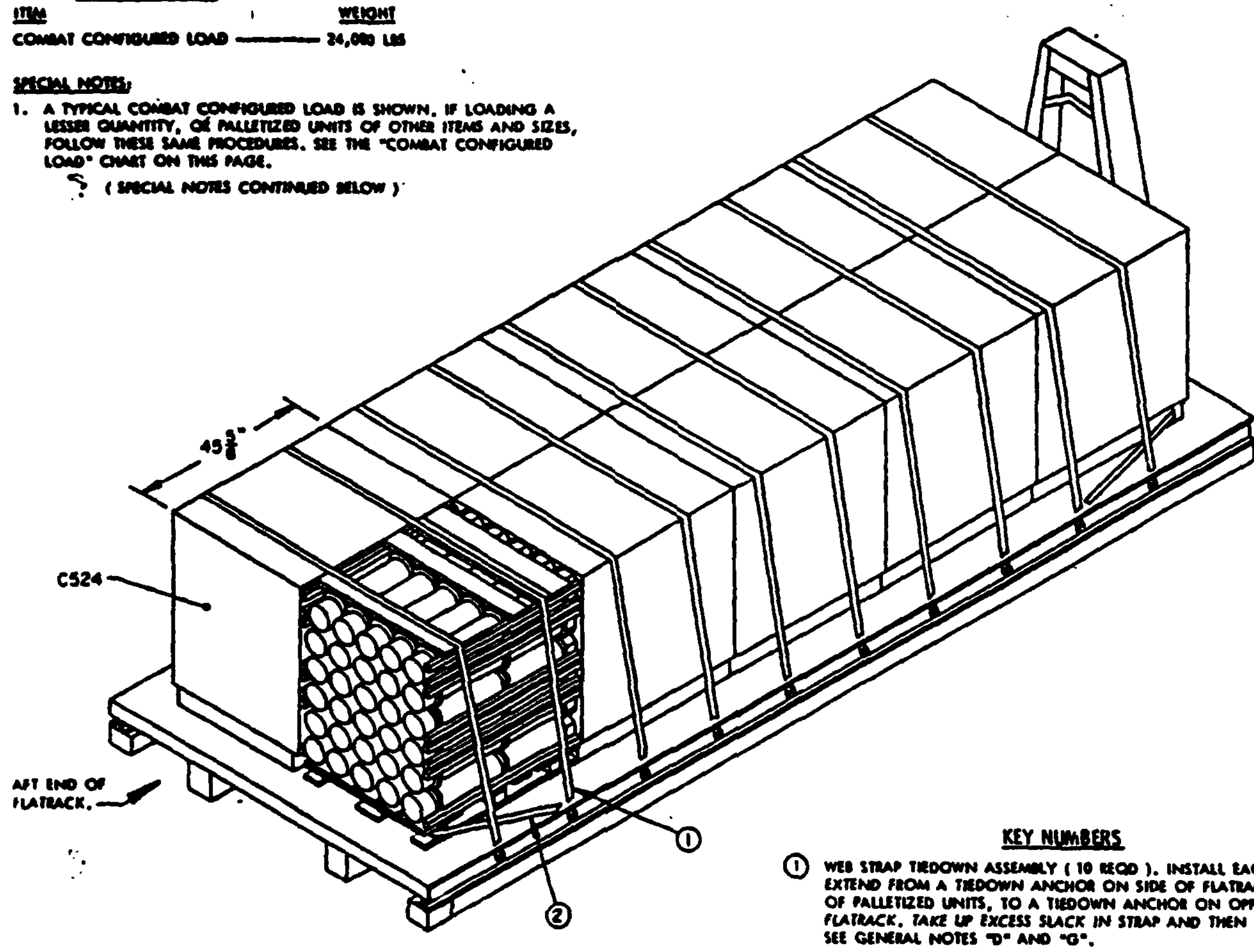
**LOAD AS SHOWN**

| ITEM | WEIGHT |
|---|---|
| COMBAT CONFIGURED LOAD | 24,080 LBS |

**SPECIAL NOTES:**

1. A TYPICAL COMBAT CONFIGURED LOAD IS SHOWN. IF LOADING A LESSER QUANTITY, OF PALLETIZED UNITS OF OTHER ITEMS AND SIZES, FOLLOW THESE SAME PROCEDURES. SEE THE "COMBAT CONFIGURED LOAD" CHART ON THIS PAGE.

( SPECIAL NOTES CONTINUED BELOW )




**ISOMETRIC VIEW**

**KEY NUMBERS**

1. WEB STRAP TIEDOWN ASSEMBLY ( 10 REQD ). INSTALL EACH STRAP TO EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF FLATRACK, OVER TOP OF PALLETIZED UNITS, TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF FLATRACK. TAKE UP EXCESS SLACK IN STRAP AND THEN RATCHET TIGHT SEE GENERAL NOTES "D" AND "G".

2. WEB STRAP TIEDOWN ASSEMBLY ( 2 REQD). INSTALL EACH STRAP TO EXTEND FROM A TIEDOWN ANCHOR ON SIDE OF FLATRACK, AROUND PALLET BASE AS SHOWN, TO A TIEDOWN ANCHOR ON OPPOSITE SIDE OF FLATRACK. TAKE UP EXCESS SLACK IN STRAP AND THEN RATCHET TIGHT. SEE GENERAL NOTES "C" AND "D".

**( SPECIAL NOTES CONTINUED )**

2. WHEN LOADING FLATRACK, CENTER THE REAR TWO PALLETS ACROSS THE WIDTH OF THE FLATRACK, AND CENTER LONGITUDINALLY BETWEEN THE TWO TIEDOWN ANCHORS TO WHICH STRAPS MARKED 1 WILL BE ATTACHED. POSITION ALL OTHER PALLETIZED UNITS TIGHT AGAINST THE REAR TWO AND EACH OTHER, LATERALLY AND LONGITUDINALLY.

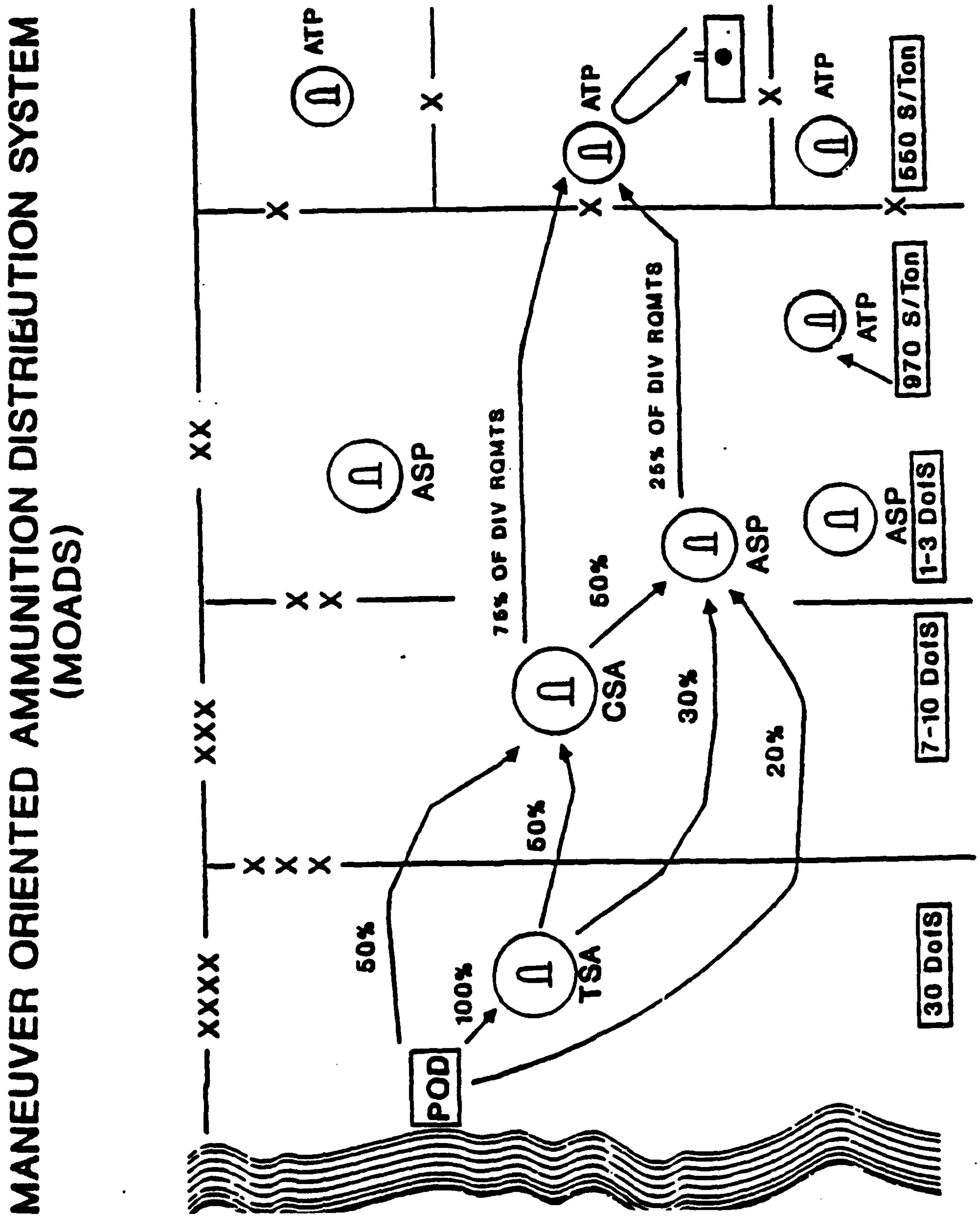
3. A TOTAL OF TWELVE ( 12 ) WEB STRAP TIEDOWN ASSEMBLIES ARE REQUIRED FOR THE LOAD SHOWN.

PRELIMINARY DRAWING

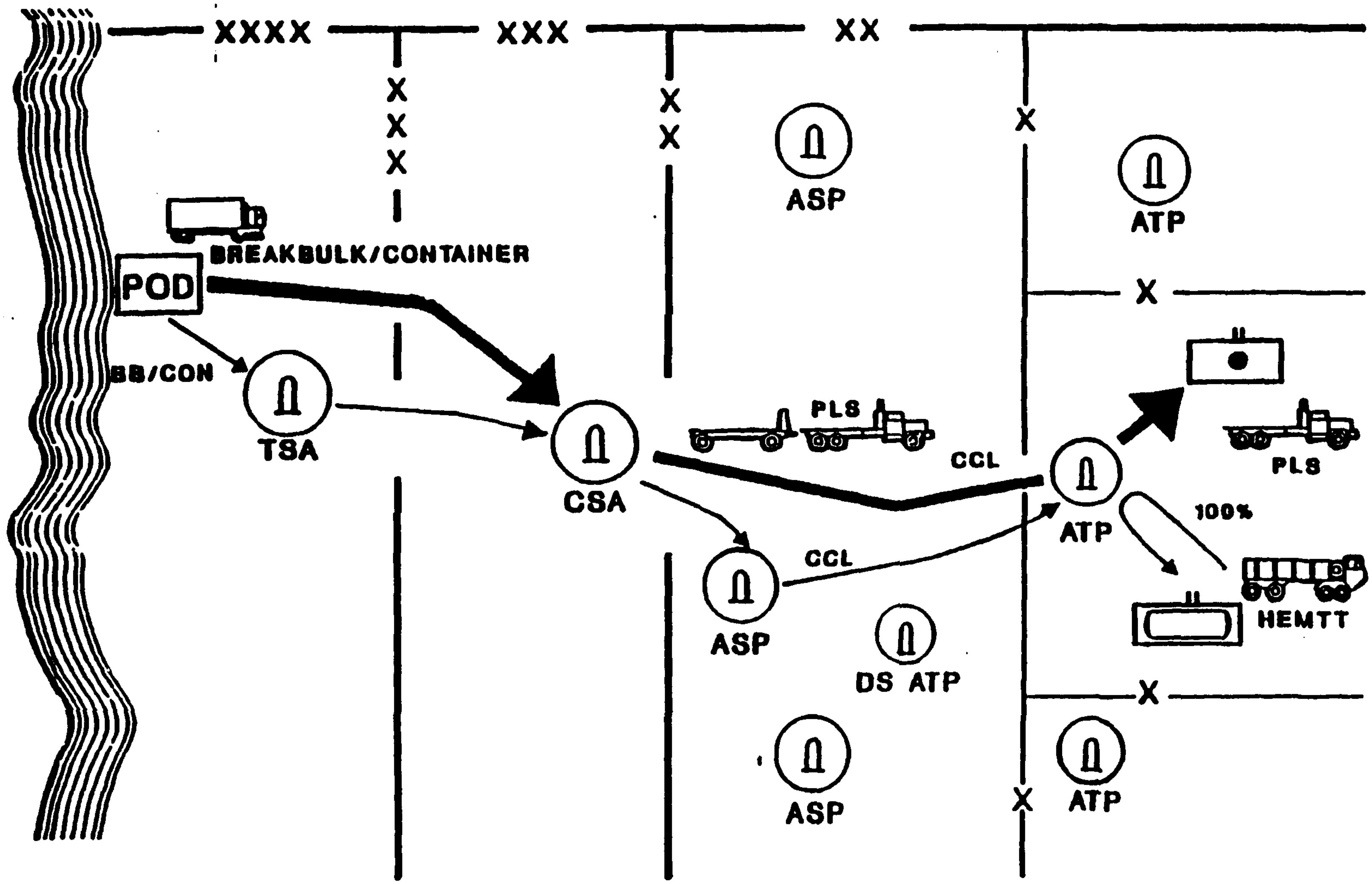
**COMBAT CONFIGURED LOAD**

| DODIC | ITEM | DIM ( INCHES ) | WEIGHT POUNDS | QUANTITY |
|---|---|---|---|---|
| C524 | CTG. 105MM, APFSDS-T, M774 | 38-5/8" X 45-5/8" X 49" | 2,408 | 10-PLTS |

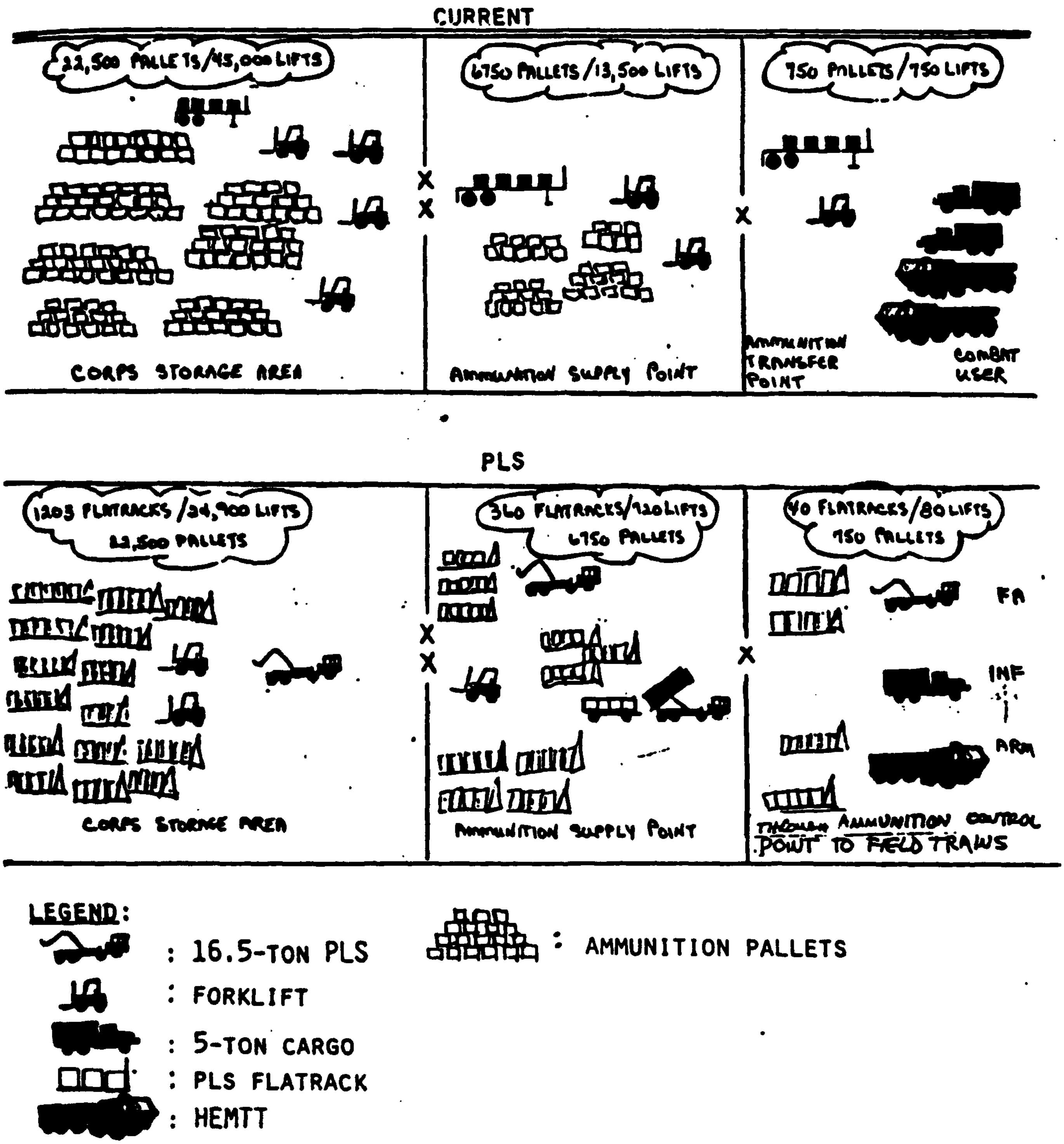
Appendix C: Diagrams of Maneuver Oriented Ammunition Distribution System (MOADS) and MOAD/PLS. (From USAOMMCS Brief: Ammunition Distribution Systems. 1991. Third chart from files of Combat Developments Directorate, US Army Combined Arms Command.)



# MANEUVER ORIENTED AMMUNITION DISTRIBUTION SYSTEM
## USING PALLETIZED LOAD SYSTEM (PLS)



## DISTRIBUTION SYSTEM (MOADS)
## CURRENT VS. PLS VEHICLES
## WHAT'S DIFFERENT?



## ENDNOTES


1. Alex Roland, "Technology, Ground Warfare, and Strategy: The Paradox of American Experience," The Journal of American History 55 ( OCT 1991 ) p. 447.

2. Ibid., p. 451. One could make a good arguement that Douhet and Billy Mitchell acted as advocates for for the innovation the airplane. Roland points out that in the 1950's, theory and advocacy were integral for nuclear weaponry.

3. Christopher D. Bellamy, The Evolution of Modern Land Warfare (London, 1990) p. 45.

4. Eric Rath, Container Systems (New York, 1973), p. 250

5. Kenneth Macksey, For Want of a Nail: The Impact on War of Logistics and Communications (London, 1989), p. 48.

6. Ibid., p. 61.

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8. Ibid., p. 137.

9. Martin Van Creveld, Supplying War (Cambridge, 1977) pp. 232-234.

10. Ibid., pp. 72-74.

11. Macksey, p. 168.

12. Ibid., p. 96.

13. Ibid.

14. US Army, Tactical Wheeled Vehicle Requirements Review of 1990 (FT Leavenworth KS: US Army Combined Arms Command Combat Developments, 29 Jan 1990), p. 2-10. (hereafter referred to as Tactical Wheeled Vehicle Review)

15. J. F. C. Fuller. Lectures on FSR III (Operations Between Mechanized Forces) (London, 1932) pp. 1 and 13: B. H. Liddell-Hart, Strategy (London, 1954) pp. 345 and 352; Mikail Tukhachevskiy, New Problems in Warfare (Reprinted by US Army War College, 1932) pp. 3, 5-7; V. K. Triandafillov, Nature of the Operations of Modern Armies (Moscow-Leningrad, 1929) pp. 14 and 19; Heinz Guderian, Armored Forces (Reprinted by US Army School of Advanced Military Studies, 1937) p. 70.

16. Richard E. Simpkin, Race to the Swift (London, 1985)

pp. 106-107.

17. Ibid., p. 148.

18. Ibid., p. 76. Simpkin viewed the heliocopter as the revolutionary development that raised the limit on the physical mobility of a military force. The rotary wing revolution that Simpkins said allowed armies to use the ground tactically without depending on it for mobility has proven to be somewhat overstated. Surface movement is not as swift. But in considering the scale of forces, it is many times as efficient as air movement and experience weather degradation to a lesser degree. Ground mobility permits forces to continously control terrain or objectives for extended periods without returning to base.

19. This was a common observation by a number senior commanders during Desert Storm reported during US Army Command and Genral Staff College presentations and by the Chief, Desert Storm Lessons Learned Activity. Older 2 1/2 ton and 5 ton cargo trucks and tractor/trailers experienced severe difficulty moving with units in the desert terrain. The newer HEMMTS and HUMMV recieved high praise for their ability to "keep up".

20. Tactical Wheeled Vehicle Requirements Review of 1990 p. 1-2.

21. Ibid., p. x.

22. Ibid., p. 1-4.

23. Macksey, p. 96.

24. John H. Mahoney, Intermodal Freight Transportation (Westport, CT 1985), p. 103.

25. Rath, p. 9.

26. Malcom Hulett, Unit Load Handling (London, 1970) p. xxiii.

27. Mahoney, p. 1.

28. Ibid., p. 188.

29. Ibid., p. 105.

30. Ibid.

31. Hullet, pp. 49-71.

32. Rath, p. 515.

33. Ibid., p. 516.

34. Ibid., p. 525.

35. US Army, Transportation 93 (FT Eustis VA: US Army Transportation School, June 1991), p. 2-14 This factor has continued to affect logistics and movement planning as evidenced from reliance on the ad-hoc Red Ball Express to reliance on Logistics Civil Augmentation Programs such as planned for NATO and implemented during Desert Storm/Shield. In both instances, the force depended heavily on expanding the central pool either with vehicles taken from other units or contracting commercial assets, with or without operators, from host nation sources.

36. Joseph M. Heiser Jr., Vietnam Studies Logistics Support (Washington DC, 1991) pp. 171-172.

37. US military forces have developed extensive agreements and plans for use of commercial strategic lift equipment or civilian workers to operate military assets. Host nation support transportation has long been planned in the European theater and was used extensively during Operation Desert Shield/Storm.

38. US Army, Operational and Organizational Plan (O & O Plan) for the Palletized Loading System (FT Monroe VA: Headquarters, U.S. Army Training and Doctrine Command, 18 Nov 83), p. 1.

39. Lewis I. Jeffries, "A Blueprint for Force Design," Military Review LXXI ( Aug 1991): p. 30.

40. US Army, Tactical Wheeled Vehicle Study p. IX.

41. Jeffries, p. 20.

42. Ibid., p. 28.

43. Ibid., p. 21.

44. US Army, Field Manual 100-5, Operatons (Washington, DC: May 1986), pp. 62-63

45. US Army, TRADOC PAM 525-5B, AirLand Operations (FT. Monroe VA: Aug 1991), p. 31

46. Jeffries, p. 25.

47. US Army, O & O Plan for PLS p. 1.

48. Janes Military Vehicles and Ground Support Equipment (London: 1985) pp. 334-336.

49. US Army, Independent Operational Assesment of the Palletized Loading System Early User Test and Experimentation- Oshkosh Truck Corporation Candidate "3" ( Alex-

andria VA: US Army Test and Evaluation Agency, Jan/Mar 1990), p. 4.

50. US Army, O & O Plan for PLS p. 5.

51. US Army, Palletized Load System Follow-on Analysis (PLS Follow-on Analysis) (FT Monroe, VA: HQS US Army Training and Doctrine Command, 26 March 1990), p. ix.

52. Memorandum: dated 7 Aug 89, Subject: Interim Operational Concept (IOC) for Class V Support Utilizing the Palletized Load System (FT Leavenworth KS, US Army Combined Arms Combat Developments Activity), p. 2 (hereafter referred to as 'IOC- PLS'.)

53. US Army, Ammunition Distribution Systems (Redstone Arsenal AL: August 1991) Chart #9. (referred to hereafter as ORD School Briefing)

54. Ibid., Chart #10.

55. US Army,. Force Development and Experimentation Report-Palletized Load System (PLS) Ammunition Distribution System, (FT Hood TX: HQS, TRADOC Combined Arms Test Activity, March 1987), pp. 40 & 119.

56. 'IOC- PLS.', p. 1. The following description of MOADS/PLS is adapted from this document.

57. Ibid., p. A-1.

58. Ibid., p. 3.

59. Ibid., p. 2.

60. This assumes that semitrailers frequently can not be piggy backed in forward areas.

61. US Army, Tactical Wheeled Vehicle Cost and Operational Effectiveness Analysis (COEA) (FT Eustis VA: US Army Transportation School [ATSP-CDC], 1987), p. E-2

62. Ibid.

63. Antoine Henri Jomini, The Art of War published in Book 2 of the Roots of Strategy Series (Harrisburg PA: 1987), p. 450.

64. FM 100-5 (1986), p. 62.

65. Ibid., pp. 62-63.

66. William G. T. Tuttle, "Sustaining Army Combat Forces Part 1." Army Logistican ( Sep/Oct 1991), p. 6.

67. Observation based on personal experience developed during Training with Industry at Lykes Bros. Steamship Company Inc. That firm operated its leased fleet of containers and chassis at a ratio of more than 5 containers to each chassis.

68. LTR DTD: 26 Mar 90, Subject: Authorization and Accountability of Palltized Load System Flatracks (FT Eustis VA: US Army Transportation School and Center [ATSP-CDC], Letter states that the PLS is restricted only for use in ammunition distribution operations.

69. FM 100-5 (1986), p. 62.

70. Ibid.

71. US Army, Field Manual FM 100-10, Combat Service Support (Washington DC: 18 Feb 1988), p. 1-10

72. FM 100-5 (1986) p. 63.

73. Ibid.

74. FM 100-10 (1988) p. 1-10.

75. Ibid., p. 1-15.

76. FM 100-5 (1986), p. 63.

77. US Army, Palletized Load System Follow-on Analysis (FT Monroe VA: HQ, USA Training and Doctrine Command, 26 March 90), p. ix. (To be henceforth referred to as PLS Follow-on Study)

78. TRADOC PAM 525-5 (1991), p. 9.

79. Ibid., p. 14.

80. Ibid., p. 31.

81. Ibid.

82. US Army, Concept for Logistic Support on the Nonlinear Battlefield (Draft)" (FT Lee VA: US Army Combined Arms Support Command, 1 Aug 90), p. 1. (Hereafter refered to as Concept for Support- Nonlinear.)

83. Ibid., p. 3-5.

84. US Army, The Battlefield Distribution System Briefing (FT Eustis VA: US Army Transportation School- Directorate of Combat Developments, 1990), p. 6.

85. US Army, PLS Follow-on Analysis- POL Applications (FT Lee, VA: US Army Quartermaster Center and School, OCT 89), p. 1.

86. William Kasper, Letter Dtd. 12 Oct 89, Subject: "Identi-

fication of Palletized Load System Requirements" (Aberdeen Proving Grounds, MD: US Army Ordnance Center and School) p. 1.

87. "PLS Follow-on Analysis", Appendix F, p. 8.

88. Ibid., Appendix A, p. 1.

89. US Army, Palletized Load System Follow-on Analysis Briefing (FT Eustis, VA: US Army Transportation School and Center, Directorate of Combat Devlopments, undated), Chart #16.

90. Tuttle, p. 8.

91. Ibid., p. 10.

92. "Tactical Wheeled Vehicle Review", p. 2-29.

93. US Army, Palletized Load System: A Vision of the Future (FT Leavenworth,KS: US Army Combined Arms Center, Combat Developments Directorate, undated briefing charts), chart # 16.

94. US Army, Palletized Load System in the Light Infantry Division Application Study (FT Eustis, VA: US Army Transportation School and Center, 22 Aug 1986), p. 2.

95. Jeffries, p. 20.

96. Simpkin, p. 5.

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